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NATURAL HISTORY IN THE GRADES

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VII AND VIII. SEVENTH AND EIGHTH GRADES

Pupils of the ages usually found in the seventh and eighth grades are much interested in those aspects of elementary science which appear in the home and community. Evidence of this attitude is seen in frequent inquiry as to how certain common phenomena occur and as to how the pupil's constructive ability may be applied to bringing about results with these common materials. This is not a new attitude. It is the inquiring and investigative attitude of the previous grades intensified by a larger outlook, and made more real to the pupil by his demand for a rational interpretation of common things. In the sixth grade all the previous experiences with plants and animals were used as the basis for an elementary study of the human body, its proper use and care. This was the elementary science of physiology and hygiene—of bodily efficiency. The same background is now used for consideration of the elementary science of the home and community. The sixth-grade elementary hygiene and the elementary-science topics of the seventh and eighth grades are educationally closely related.

Topics that are appropriate for study in these grades vary with the region. In an agricultural community emphasis may well be placed upon elementary agricultural science, while in other communities other industries and interests furnish vital problems. Some of the essential elementary problems, however, are almost universal. Topics of importance that are not readily divisible into agricultural and manufacturing groups are: the phenomena of boiling, refrigeration, distillation, solution, crystallization, water supplies, steam and its applications, heating and heating systems, heat measurements, the atmosphere, chlorophyll work of plants, the most important plants in the world's food supply, the domestication of plants and animals, energy and the machines by means of which work is done. They are of universal importance, and if studied in an experimental and investigative manner and not didactically they have universal educational value.

There are at least three factors that must be kept in mind as essential for work in these grades. They are: first, the possibility of experimentation which may be performed in such a way that accurate observation and inference may be required; second, the constructive and inventive capacity of pupils must be called forth, preferably by actually demanding that they devise some apparatus, and at the least by demanding interpretation of processes and apparatus devised by others; third, the topics must involve knowledge that appeals to the pupils as being worth while. On this last point it must be recalled that pupils of this age are not so much interested in a scientific arrangement of facts as they are in learning about the scientific import of common matters. Facts as children see them are not classified into the different grooves that we choose to call the different sciences, but they see the topics of interest and desire an interpretation of the phenomena that are involved regardless of the particular science that is needed for the explanation. It may be questioned whether some of the topics suggested allow all three of these factors to be used. Certainly the proportionate use will vary. In such a topic, however, as the history of the domestication of plants and animals, printed matter must be looked upon as the records of the experiments of others; and illustrative material—charts, pictures, etc.—must be secured therefrom so that a connected story of any given plant or animal may be constructed. One seventh-grade boy in his work collected a large stack of pamphlets, made lantern slides, and presented to his fellows several highly interesting discussions upon the sugar-producing plants of the world, thus showing that printed statements may be very real things and may become the basis of new constructive effort in the form of a graphic report.

It is important throughout this work that the pupils keep carefully made notes upon experiments and observations. A notebook specially for the elementary science should be kept. This will not only be of great advantage in securing careful attention and accurate observation but should give at this early period methods of recording things in brief, pointed, and well-written notes. This book should also contain, in every possible case, sketches of apparatus used. Oftentimes carefully prepared sketches are much more valuable than notes, since one can often write something that while not wrong does not tell all the truth, but in making sketches lines will not go together properly unless accurate seeing has preceded. Both notes and sketches should be brief but accurate.

The general plan of work that is here presented has been used with variations for three years. Further experience will doubtless necessitate other changes. The topics that have received major attention in one year have not always been the ones to receive such attention the next year. During the past year the teaching in these grades of the Elementary School of the School of Education was done largely by Mr. H. R. Halsey.

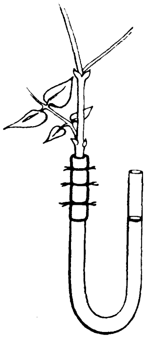
The following outlines are partly the outcome of Mr. Halsey's experience, and partly the outcome of observation and experience of others in the same and preceding years.

SEVENTH GRADE

The general topics used in the seventh grade include an elementary study of the meaning of chlorophyll to plants; the nature of different soils in their relation to plant life; some of the processes by means of which a plant lives—root and leaf absorption, conduction through the stem, evaporation and transpiration, and the elementary chemistry of food-manufacture by means of chlorophyll; surplus food, food-storage and its significance to other living things; the special growth and food-storage habits of man's domestic plants; the history of domestication of domesticated plants and animals, and the present methods of their improvement through cultivation, transplantation, and breeding. A study is made of the forms of energy that are used in the industries with electricity as a type; an experimental study of electricity and electrical apparatus; manufacture and use by pupils of simple electrical apparatus.

The work may begin by a study of the nature of a plant —its roots, stems, and leaves—or by a study of the leaf of a plant, or by use of plant-responses, as wilting, transpiration, root-pressure, or by a study of the soil in its relation to plant-activities. If we begin with the soil the first experiments to be performed are those with the structure and water-holding capacity of soils. Qualitative experiments with reasonable approximation of quantitative results are employed. One series of experiments relates to water-holding power and the other to water-lifting power. Secure a given quantity—e.g., one quart—each of sand, loam, and clay and weigh carefully. Place where they will dry rapidly, and weigh from day to day. (If artificial heat can be used in drying, more accurate results may be had in a short time.) Each pupil should note the amount of water evaporated from each kind of soil. In closing this experiment pour upon each kind of soil the amount of water that was found to be evaporated from it and observe the amount again absorbed and the relative rate of this absorption. After having prepared thoroughly dried samples of each kind of soil, place each in a glass tube that is at least an inch in diameter, tying cloth over one end to hold the soil. Stand the three tubes in a dish of water and determine the rate at which each lifts water. A similar set of tubes is used to investigate the rapidity with which water passes downward by pouring water into the tops of the tubes. The observations and inferences from these experiments demand careful observation and discussion and constant reference to the life of plants in these soils. Mixed soils and organic matter in the soils should receive attention, but to be studied in detail require too prolonged work for pupils of this grade. Explanation of the significance of surface cultivation of soils both in garden and field as well as the significance of dry-land farming is based upon these experiments, and should be given in this connection.

How plants take up soil water and the things that are in solution in it cannot be answered fully by experiment at this time, but two or three simple experiments form the basis for interpretation of what is known of the process. First a stem and leaf lifting experiment (Fig. 1) is performed by cutting off, under water, the top of a potted plant. It should be cut so as to leave about one and one-half inches of the stump. A relatively hard-stemmed plant, as the geranium, Indian corn, or a woody plant, is best. Then by handling the plant and tubing under water so as to avoid getting air into the plant or tubing, attach the stem by means of rubber tubing to one arm of a U-shaped glass tube, making certain that the glass and rubber tubes are entirely filled with water. The connection should be made air-tight by carefully tying the rubber-tube collar about the base of the stem and the top of the tube. Remove the plant and tube and support them carefully upon a ring-stand and observe whether the water in the tube disappears. Secondly, attach in the same way to the stump of the plant, not necessarily under water, a straight piece of tubing (Fig. 2), keep the roots watered, and note results. By means of these experiments it will be



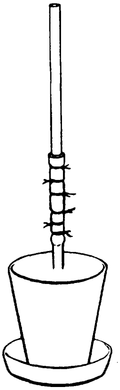
Drawing by Amy Rachel Whittier

FIG. 1.—A simple device to test the power of a stem to lift water

found that roots force water upward and that leaves and stems lift water.

Several other demonstration experiments may be made. Chlorophyll may be dissolved from the leaf by alcohol. Chlorophyll containing cells of a leaf or of algae should be shown the class. Starch food may be demonstrated, if present, by use of an iodine test, first having treated ordinary starch with iodine to show the characteristic color reaction.

These experiments form the basis for a discussion of the work of chlorophyll. Pupils of this grade greatly enjoy learning the simple chemistry that may be used in this connection. The chemical formulae for water, carbon dioxide, cane sugar or glucose, and starch are introduced. It is clearly stated that many intermediate chemical changes occur before sugar and starch are made, but that these are too difficult for our study. We deal with the initial materials and final results in order to make a basis for a general interpretation of the significance of plant work. Electrolysis and synthesis of water have twice been used as a demonstration of chemical change, and if the apparatus is set up before the class and the pupils are called upon to observe and explain phenomena, an intensely interesting exercise is had.



Drawing by Amy Rachel Whittier

FIG. 2.—Apparatus for testing the ability of plant roots to force water upward

The relation of surplus food of plants to dependent plants (toad-stools and mushrooms, plant parasites, etc.), to animals, and to the world's food supply in general is given brief attention. The book by Carpenter on *How the World Is Fed,* published by the American Book Company, offers valuable reading material upon this topic. This readily leads to a brief study of the history of domestication of plants and animals. It is not intended that this should be a study of the biological evolution of domesticated plants and animals, but a study of whence and how came these forms in man's experience with them. This study should be associated with an investigation of the regions and methods now employed in best production of domesticated plants and animals. Different aspects of this topic should be assigned to different pupils, making certain that there is available source material for each topic assigned. First in class discussion there is prepared a list of the most important domesticated animals and plants—horse, cow, pig, poultry, corn, wheat, potato, apple, tulip, rose, etc. (The fifth-grade course includes a study of the use of these to men, therefore that aspect may now be reviewed as a basis for further work.) The problem of ascertaining whence and how they came, where and how they are now being grown and improved, must be clearly defined. Then each pupil is assigned one topic, and each is given definite direction as to how he may begin his work. To most pupils should be handed but one or two references upon which they should report to the class. Some should write to experiment stations or commercial firms for their data. In some cases interesting work is done by having pupils correspond with pupils in regions where work upon some of these topics is going on. As in the case of the nature of the growing cotton plant, valuable co-operation with a southern schoolboy might readily be arranged and letters and samples of importance and interest thus secured.

If possible, schoolroom or garden experiments in cross pollination should be made, though with our facilities not much can be done. Experimental horticultural work in this connection would doubtless be highly valuable. In previous garden work, however, a study of pollination and seed-formation was made and the facts then gained are now used as a basis for an understanding of how cross breeding of plants is effected. Some of the results of plant and animal breeding will have been developed in the special studies but the general topic should be discussed. One or two of the conspicuous triumphs of plant-breeders, such as in increasing the oil or starch content of corn and in production of hardy oranges, should be studied.

It is desirable that there be prepared for reading simple accounts of the domestication, present conditions, and methods of improvement of plants and animals of universal importance. Such accounts if made available would enhance the efficiency of this phase of elementary science.

The study of chlorophyll and its utilization of part of the sun's energy in food-making should in this grade be accompanied by a study of a form of energy which has wide mechanical possibilities and which offers opportunity for use of the pupil's inventiveness. For this the topic of electricity is used. It has seemed necessary to have most of the experiments performed before the class, these being performed by a group of pupils or by the teacher. Demand for explanations should always be preceded by an experiment or demonstration. There are few appliances so well known that their previously observed working can be recalled with sufficient accuracy to serve as a basis for discussion. Most of the children have access to some electrical apparatus at home, and several have purchased apparatus. Any who wish are allowed to go into the elementary-science room after school hours and try experiments, and several have often availed themselves of this opportunity.

Various initial experiments have been used with different classes. The study of magnets or of the dynamo offers excellent beginning topics. In the past year an explanation of electrical appliances was called for with the incandescent carbon-filament lamp as the first instrument that was used. Most of the class had handled the lamps and thought they could explain how they work. A few minutes occupied in attempts to explain, however, convinced the children that they needed to understand several things before they could give a satisfactory explanation. Electric bulbs were passed to the class and the plan of construction called for. The pupils were exacting in their demand for clear explanations from one another and few statements were allowed to pass unchallenged. Experiments with the socket and use of the key were made at school and at home. Drawings illustrating the mechanism and the course of the electric current through the filament were finally made by the children and much interest was shown in explaining these drawings.

The arc lamp was next investigated and gave little difficulty, although there was needed help from the teacher in explaining the flow of current when the carbons were separated. The automatic regulating device was left until later when electromagnets were considered.

Magnets were next taken up. Different articles were tested for magnetism. Individual experiments were made with the usual compass and iron filings apparatus. Various magnets were tested to determine their polarity. A broken magnet compelled most of the children to rethink their conclusions already formed. An electromagnet was then examined and the relation of polarity and direction of current discussed. So far the current used had been taken from the light mains in the classroom. At this point experiments with batteries as sources of curents were taken up. The dry, Daniel, and storage forms were used. Each type was studied both from the point of what it does and of how it is made. Many of the pupils constructed wet cells of various types. Then followed applications of the electromagnet—the telegraph, electric bell, motor, dynamo, telephone, automatic clutch for the arc lamp, etc. In case of the first three the pupils were given the problem of devising a piece of apparatus to accomplish the end stated. The solution of the telegraph came promptly. The electric bell was more difficult. Plans were presented by means of board drawings, and criticisms from the class uncovered the faults until several quite different but acceptable plans were developed. Some of these were very original. The keen and pointed criticism of the class indicated insight into the factors involved (Plate I, Fig. 1).

Devising a motor was the most difficult problem. Some suggestions were given, but the keen interest of the boys especially served to bring out a large number of suggestions so that several types of motors were planned. Finally a half-dozen different types of motors were brought into the class and studied. More than one-half the pupils bought the parts of the small Ajax motors and wound and assembled them, thus constructing working motors. A small hand dynamo was used in running the motors.

Some of the pupils suggested that a motor might run a dynamo which in turn might run the motor. This occasioned vigorous argument and presentation of evidence and the claim was of course disproven.

Telephones were brought into the room and studied, but not all the pupils got a good understanding of the instrument. Different types of lamps were used—the mercury lamp (for which an original plan for an automatic tilting device was devised by one of the boys), the Tungsten, Nernst, and flaming arc, and their cost of operation was compared with that of the carbon-filament lamp. This work of course involved calculations and the use of the units, ampere, volt, and watt, in which the pupils took great interest. Numerous problems involving cost of currents for various instruments were given and solved with readiness and accuracy.

The wireless telegraph appealed to some of the boys more than did any topic. Two weeks were spent on the instrument, at the end of which time at least a dozen boys had outfits in operation at their homes. Some succeeded in passing and receiving messages over a distance of two miles. Higgins' *Elementary Science*, published by Ginn & Company, contains many valuable suggestions for the elementary physics of the seventh and eighth grades.

EIGHTH GRADE

The topics in elementary science that have been found useful in this grade are: The phenomena of boiling, condensation, the distillation of water, expansion and contraction; steam and its uses; heat energy, the sources from which, in the industries, heat is derived; manufacture of gas from coal, wood, paper, etc.; combustion and oxidation (rusting); temperature measure-

PLATE I

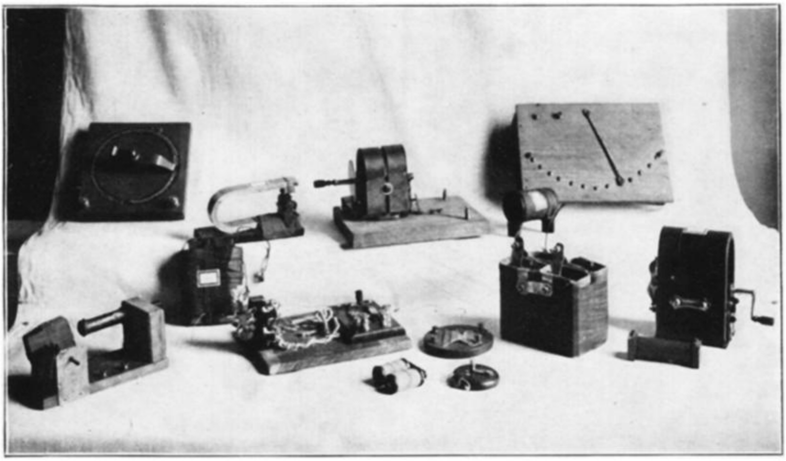


Fig. 1.—Electrical Apparatus Made by Pupils in the Seventh Grade

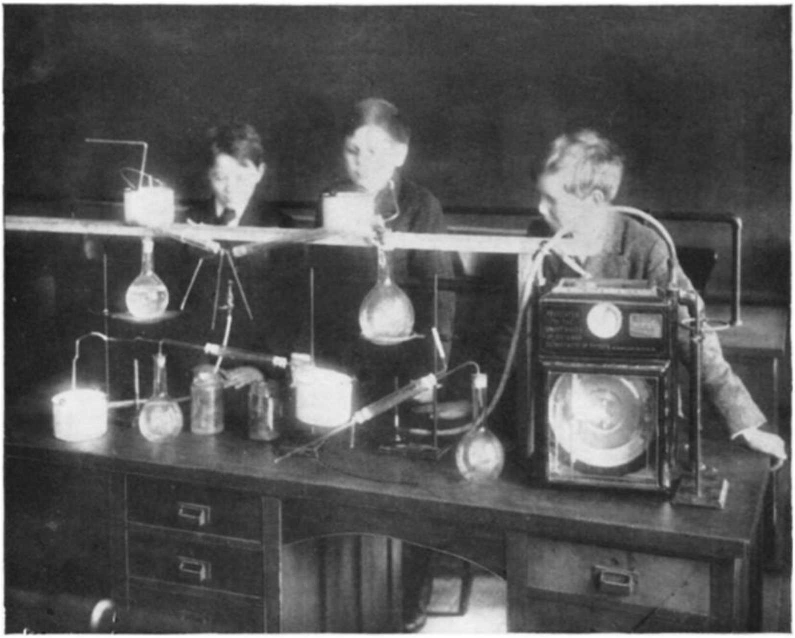
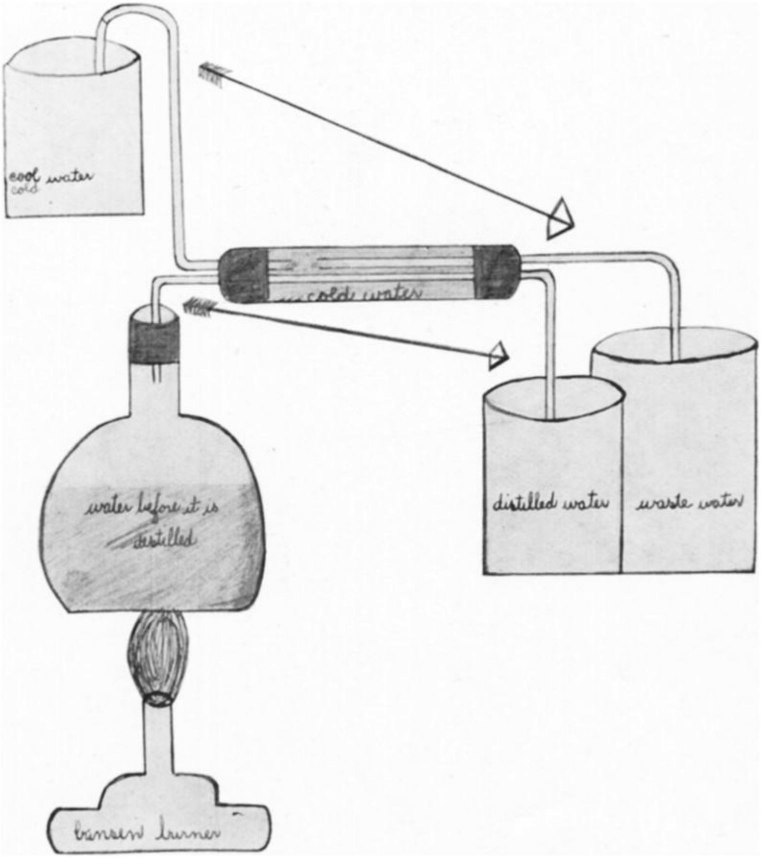


Fig. 2—Eighth-Grade Boys Constructing Apparatus with Which to Distill Water

The apparatus is in focus which throws the pupils slightly out of focus

PLATE II



A Boy's Diagram of His Distilling Device, Made After the Apparatus Was Constructed

This is one of the best of the diagrams received in this work. Below is a copy of a calculation that was made and turned in as part of the report of one pupil. The part of the report given is only that which relates to the use of the apparatus in determining the cost of using the pupil's apparatus:

I burn gas at the rate of 1 cent every 2 hours. I distill 4 oz. every 15 minutes or 1 pint every hour, or a quart every 2 hours, therefore costing 1 cent a quart.

Distill 4 oz. in 15 minutes.
16 oz. or 1 quart in 60 minutes.
1 quart in 2 hours.
1 gallon in 8 hours.

It cost 1 cent every 2 hours. Then it cost 1 cent for every distilled quart, or it cost 4 cents for every distilled gallon.

Hydrox costing	$0.10 per gallon.
My way costing	$0.04 per gallon.
I make	$0.06 per gallon.

ments and construction of thermometers. The atmosphere, its elementary physical and meteorological phenomena; precipitation; the barometer; wind energy; pumps; light, its relation to food and energy of the world as already shown in chlorophyll work, and some of its phenomena and reactions as shown in a study of photography. The elementary science of some of the materials of the industries, as fibers, paper, glass, rubber, paint, etc. An elementary study of forests and forest influences upon soils, waters, climate, health, animal and plant life; the timber industries (topic opened in the fifth grade), the regions of the world's leading forests, methods and reasons for extending forests.

The study of heat may well begin either with an experiment in boiling or one in expansion of solids. In the first case a tea-kettle and an open pan operated in boiling water before the entire class afford excellent beginnings. In expansion of solids the ball and ring experiment is good. In studying the phenomena of boiling it is best to use a standard thermometer, simply stating in case questions arise that later the working of the instrument will be considered. It is helpful, however, to record temperatures of water in different stages of experiments. First boil the water in the tea-kettle and secure as complete observation and interpretation as the pupils can make. Close the spout of the tea-kettle and repeat the experiment. In the open pan slowly bring the water to the boiling point and ask pupils particularly to study the occurrences at the surface of the water. Accompany these observations with an experiment in weighing a pan of water before and after boiling. By collecting steam in a cold tube and noting the resulting condensation of water the problem of distillation is introduced. Plans for the manufacture of a miniature still from common laboratory materials are called for. Drawings of proposed plans have been required in some cases before experimentation and in some cases after building an apparatus (Plate I, Fig. 2). Better thinking and more efficient experiments seemed to come from first devising a plan on paper, although in amost every case the plans had to be changed before a working apparatus could be built. Some of the stills were built so well that it was possible to distill water and by means of a gas meter to determine the cost of distillation by means of this apparatus (Plate II).

During the past year instead of experiments in distillation more attention was given to the use of steam engines. Most of the pupils knew a little about engines, but rational explanations were absent. The cylinder and piston of a steam pump were first assigned and were readily explained. The stride valve, thus making locomotion possible, was added by several who doubtless had numerous observations from which to draw. Models and drawings were then placed before the class. A large model of the chest valve, valve cylinder, and revolving mechanism was borrowed and proved of much interest and value. The construction of the boiler was explained and discussed in its relation to the other parts of the engine. Pupils then made drawings illustrating the construction and action of various parts of the steam engine, and carefully written statements in explanation were prepared. In connection with the experiments made by one class upon distillation, the construction of thermometers was taken up. The principles involved and methods of gradation were discussed and different types of thermometers were constructed. Some of these were graded in the Fahrenheit system, some in Centigrade, and some in systems devised by the pupil. In all cases the pupils transferred the value of units in their readings into terms of other units. The accuracy with which these thermometers were made is shown by the fact that although some of the thermometers were several degrees away from standard readings the average taken from all the instruments made by the class was less than one degree from the standard reading.

In the manufacture of gas from various substances further illustration is had of the method of study. Ordinary clay pipes were filled, some with soft coal, some with wood, and some with paper. The bowls of the pipes were cemented with ordinary cement or with potter's clay. When dry these were fastened upon ring stands and the bowls slowly heated by a gas flame. From some of the pipe stems there soon appeared a jet of smoky gas. To this a lighted match was applied, when it began to burn. If the flame under the bowl is removed the gas soon ceases to be formed, and if reapplied it begins again and continues until the gas-forming properties of the material are exhausted. The pipe bowls are then opened and the charred contents examined. An explanation of these materials and occurrences is thought-stimulating and provides a basis for an understanding of other gas-forming materials and processes.

The nature of combustion and oxidation follows. During the past year three weeks were given to laboratory work with oxygen, the meaning of oxidation, and methods of aiding and preventing it. Carbon dioxide followed and as in the case of oxygen was studied in experiment and in discussion of the place of this gas in nature and industry. There are taken up various experiments with the atmosphere relating to its reality, weight, pressure, expansion, and contraction, pumps, water-carrying power, and currents. Previous work in geographic aspects of the atmosphere is called for. The construction and reading of weather maps are studied. As suggested above, photography is used as a means of studying light, this topic also receiving more time during the past year than previously. Some general discussion of photography leads to the pinhole-camera experiment. Each pupil constructed a pinhole camera, securing therefor a starch box or a similar box. The nature of light action through prisms and through lenses was discussed. The action of light upon a sensitized emulsion and the mechanical and chemical processes involved in developing and printing were discussed. Each pupil took a picture and carried it through each requisite process to the final print. Most of the pinhole cameras leaked light, but a few good pictures were secured. Several of the pupils secured notions of the fundamentals involved in photography which, in addition to being instructive, will in the use of their own cameras prove useful to them.

A list of the important industries in and about Chicago is prepared by the class, and each pupil or group of pupils is assigned one industry and is asked to prepare a brief report concerning the raw materials used, the processes and machinery involved, and the final and by-products made in the industry. The lumber industry is omitted from these assignments and is made the topic for a more extensive study. Five weeks were spent last year in a study of elementary forestry in this country and in Europe. A review of local native trees, and of local lumber supplies (discussed in geography course), and of how a tree grows, is followed by assignment of readings from pamphlets and library books. Much of the study must be entirely classroom work contributed largely by the teacher, since experience of pupils and reading material for pupils of this age are not abundant. There are, however, available discussions of forest needs and influences, photographs, and descriptions of what is being done in various parts of the country in forest extension and in withstanding forest enemies. Forest fires, predatory insects, and unnecessary commercial destruction are of interest to all. *The Primer of Forestry,* by Gifford Pinchot, U.S. Department of Agriculture, is valuable for this work. The U.S. Forest Service also publish a list, in a bulletin which cites many available helps in such work. And *Care of Trees,* by B. E. Fernow, published by Henry Holt & Co., 1910, is full of authentic practical suggestions.